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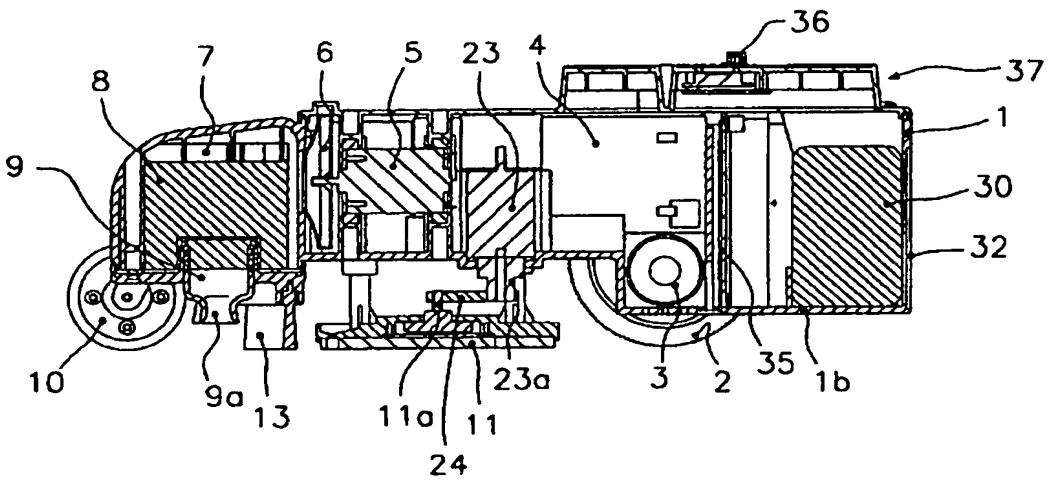
(54) Title: AUTOMATIC FLOOR CLEANING DEVICE



(57) Abstract: An apparatus for cleaning floors comprising a floor cleaning element support (11) is slidably connected to the frame (1) in such a way to be kept in contact with the floor or to be raised therefrom. Floor discontinuity sensing means (20, 21) comprise at least a sensor (20) for detecting discontinuities of a thickness lower than the minimum distance of the body (41) from the floor and generating a signal for raising the cleaning element support (11). Control means (35) are provided for converting the operation of the apparatus from a random operating mode to a spiral operating mode as a function of the time elapsed between two subsequent collisions and to control its operation when collision or discontinuity signals are received and when the battery is being discharged or another room has to be cleaned.

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TITLE

AUTOMATIC FLOOR CLEANING DEVICE

DESCRIPTION

Field of the Invention

The present invention relates to the field of floor cleaning equipment, in particular household floors, and more precisely it relates to an automatic apparatus for cleaning floors.

Description of the prior art

It is well known that these apparatuses can be equipped with a vacuum system for the removal of dust and small residues or with means for washing and/or polishing floors. In any case, these apparatuses must be controlled by an operator who provides to their locomotion and orientation.

Fully autonomously operated floor cleaning apparatuses are also known. WO00/04430, US 5781960, US 5940927 and US 5568589 disclose apparatuses of this type. Substantially these apparatuses comprise a cleaning device, an electric supply and motor means driving a pair of wheels for their motion. Navigation sensing means allow the apparatus to move on the surface to be cleaned detecting obstacles and emitting signals indicative of their presence which are received by a motor control system.

Some of these apparatuses are designed for dirt and dust removal only, while other are designed for treating the surface with special substances such as detergent, deodorant, antibacterial products and the like, for example as described in WO 00/04430.

These devices are comparatively complex as far as their construction, operation and control system are

concerned and therefore their cost is too high as compared with their intended use. Moreover it is a general requirement that this type of apparatus would exhibit a power consumption as low as possible to prevent frequent operational stops for their recharge.

Summary of the Invention

The object of the present invention is to provide a floor cleaning apparatus, motorized and autonomously operated, capable of performing, at the same time, the removal of dirt and dust and providing the detersion of the surface to be cleaned, while reducing to a minimum the electric power consumption and requiring an effective and inexpensive control system.

Another object of the present invention is to provide an apparatus of the above-mentioned type able to pass around any obstacle it may contact during its movement and to change its movement direction when encountering a discontinuity on the floor.

A further object of the present invention is to provide an apparatus of the above-mentioned type equipped with a device for treating the surface to be cleaned with a detergent liquid which is able to stop the detersion operation when crossing prefixed portions of said surface, in particular those covered by a carpet.

A further object of the present invention is to provide a method for cleaning floors and a method for controlling the operation of the cleaning device of the above-mentioned type which allow the electric power consumption to be minimized and various operating modes to be optimized.

A particular object of the present invention is to provide a method for cleaning floors and a control method

of the above-mentioned type wherein the operation according to different operating modes is allowed as well as the automatic passage from one to another one, wherein the cleaning of a room can be automatically stopped after a prefixed time and started a search mode for finding a passage toward a room still to be cleaned, and wherein a recharge station can be automatically reached, all these functions being performed with the aim of optimizing the apparatus performances.

The above objects are reached with the vacuum cleaning apparatus for floors according to the present invention, with the relevant method for controlling its operation and the method for cleaning floors which can be carried out thereby, the essential features of which are set forth in claims 1 , 11 and 16. Further advantageous features are set forth in the dependent claims.

Description of the drawings

Further features and the advantages of the vacuum cleaning apparatus according to the present invention will become more apparent from the following description of an exemplifying, non-limiting embodiment thereof, made with reference to the attached drawings, wherein:

- Figure 1 is a plan view of the apparatus according to the present invention, the external body thereof being removed for clarity;

- Figure 2 is a side view of the apparatus of figure 1;

- Figure 3 is a longitudinal sectional view taken along lines II-II of the apparatus of figure 1;

- Figure 4 is a plan sectional view of the apparatus of the invention according to lines IV-IV of figure 2;

- Figures 5 and 6 are front and rear perspective

assembly views of the apparatus according to the invention;

- Figure 7 is a perspective view of the apparatus of the invention with the relevant external body;

- Figures 8a and 8b schematically show a collision detector of the electromechanical type in normal operating condition and in a contact condition respectively;

- Figure 9 is a block flow diagram showing the operating mode in case of a collision or a detection of a discontinuity;

- Figure 10 is a block flow diagram showing the operating mode in case of detection of a carpet;

- Figure 11 is a block flow diagram showing the operating mode in case of detection of a low battery charge level.

With reference to figures 1-6, 1 denotes a box-like frame of the apparatus mounted on a pair of rear wheels 2 driven by independent electric motors 3 axially arranged and fixed to frame 1, whereby wheels 2 are both independently driven. Frame 1 is supported at its front end by a pair of wheels 10 fixed to frame 1 in an articulated way on respective vertical axes 10a.

A pair of rechargeable batteries 4 is located on frame 1 and over motors 3 of wheels 2 and before batteries 4 a third motor 5 is longitudinally located for driving a fan 6 situated in a substantially central position on frame 1. Fan 6 is in a suction engagement with a chamber 7, in which a conventional, air permeable, filtering bag 8 for dust collection is arranged. Bag 8 communicates with a conduit 9 for sucking any dirt from the floor, and suction inlet 9a thereof ends at the underside of frame 1 and faces toward the floor. Suction inlet 9a is placed before

a brush collector 13 extending side-to-side of frame 1 and having a substantially V-shaped, very spreaded outline so as to collect dirt during the movement of the apparatus and convey it toward its middle portion before which suction inlet 9a is placed. Bag 8 is accessible for replacement from the lower side of frame 1, by removing a cover 1, from which suction inlet 9a protrudes.

A plate 11 is located under frame 1 at an intermediate position. Plate 11 bears a cleaning cloth, not shown, for example of the type conventionally shaped like a cap to allow it to be manually secured to plate 11. Plate 11 is hang to frame 1 by means of two pairs of stems 12 slidably mounted in tubular seats 1a of frame 1 formed at both sides thereof. Plate 11 and the relevant cloth can freely lean on the floor by virtue of its own weight or, preferably, elastic means (not shown) can be provided between plate 11 and frame 1 to ensure a moderately forced contact with the floor. Advantageously the perimetrical edges of plate 11 are bent toward frame 1 both to make easier the application of the cleaning cloth and to assist in overcoming small obstacles of the floor without the risk that plate 11 would jib against them.

A small tank 30 for sanitizing liquid, detergent or the like is located at rear side of frame 1 and is connected to a dispensing pump 31 through a pipe not shown. Pump 31 dispenses liquid on the cleaning cloth, continuously or stepwise, through holes or slits not shown formed on plate 11.

Preferably, tank 30 is made of transparent material so that the level of liquid may be checked through a window 31 formed at the rear side of frame 1. Tank 30 may be filled in through a cap 33, which can also be formed by

a capsule containing a dosed amount of detergent or other substance to be solubilized in water when necessary.

Plate 11 is centrally provided with a connection member 11a connected to stem 23a of an electro-magnet 23, by means of a bracket 24 in the present embodiment, located between motor 5 and batteries 4. As a result of a suitable electric signal to the electromagnet, plate 11 can be lowered and raised as required, as better explained hereinafter.

The bottom side 1b of frame 1 is formed with a plurality of slits 34 through which the air sucked by fan 6 comes out and is projected on the treated surface, thus assisting in its drying.

The system for driving the apparatus is assembled on a circuit board 35 which also includes a microprocessor implemented with a management software that can be updated through serial connection 36 placed on a control panel, generally indicated at 37, arranged on frame 1 and comprising a display 38, a control keyboard 39 and an instruction board 40.

The apparatus further comprises an outer body 41, shown in figure 7 by way of example, elastically fixed to frame 1. Outer body 1 conceals the frame and rear wheels and is provided with a transparent cover 42 to have access to control panel 37.

The apparatus according to the invention is equipped with three groups of sensors which have the task to control the movements thereof. A first sensor is formed by a collision sensor 15, for example of the magnetic type, formed by a switch 18 operated by a magnet, not shown, fixed to body 41 correspondingly. As a result of a collision of the body with an obstacle and thanks to the

elastic connection of body 41 to frame 1, the displacement of body 41 moves the magnet away from switch 18 and opens the electric circuit on which switch 18 is mounted. As an alternative, collision sensor 15 may be of the electro-mechanical type. As shown in figures 8a and 8b, the collision sensor 15 comprises an angled bracket 16 having a free end 16a which is fixed to body 14, while the other end 16b is linked to box 15a of sensor 15. By means of a spring 17 angled bracket 16 is forced against a switch 19. In this case a pair of collision sensors 15 is provided preferably located on frame 1 approximately above rear wheels 2. Figure 8a illustrates the condition of normal operation, while figure 8b represents the situation occurring when body 41 bumps against an obstacle. The resulting cut-off of the electric current associated to switch 18 or 19 constitutes a signal which is processed in the electronic control system of the apparatus to provide motors 3 with a selective control signal to immediately stop the forward motion of the apparatus as described hereinafter.

As an alternative, infrared proximity sensors may be used as collision sensor, arranged along body 41 to be activated before the apparatus bumps against an obstacle.

A second sensor, which the apparatus is equipped with, is intended for detecting low obstacles, i.e. surmountable by the apparatus as being of a thickness lower than the minimum distance of the body from the floor In the example shown in figure 1 the second sensor comprises a pair of infrared proximity sensors 20 mounted on a bracket 21 extending frontwise from frame 1. Sensors 20 detect, in particular, the presence of a carpet and can activate a lifting movement of plate 11 to prevent the

cloth applied to it from coming into contact with the carpet either as soaked with detergent substances or to avoid an excessive friction.

A third group of sensors, which the apparatus is equipped with, has the function to detect any floor discontinuity consisting of lack of supporting surface, such as a step. In the present embodiment of the invention two discontinuity sensors 22 are provided,which are fixed on bracket 21 at the outside of sensors 20 before front wheels 10. Sensors 22 are infrared proximity sensors onwardly oriented and downwardly inclined, while sensors 20 are vertically downward directed.

For example, in the presence of an approaching step, sensors 22 emit a signal for starting a stop procedure of the apparatus forward motion as explained later on.

The apparatus can be manually or automatically connected to a battery recharge unit, not shown. In the first case, the apparatus is on during the recharge, but, once it is charged and disconnected, a start and, possibly, pause button must be pressed to start it. In the second case, once the batteries are charged, the apparatus automatically starts.

The apparatus moves always straight forward at a preset speed and with the suction system on or off and capable of temporarily being started in case of a collision only, so as to reduce noise and energy consumption.

The operating control modes of the apparatus according to the invention are essential to the aim of achieving the objects of the invention. The operating sequence of the various operating conditions is shown in the flow diagrams of figures 9, 10 and 11.

The apparatus is programmed for a combined random/spiral operating mode, to minimize the number of passages on the same surface portion without leaving untreated surface portions in the stated period of time of permanence in a certain room. The passage from a random operating mode to a spiral operating mode is decided when the time interval Δt between two successive bumps exceeds a prefixed value t_u.

In figure 9 there is shown the operating mode when a bump occurs or a surface discontinuity due to a stair step is detected. The apparatus reacts to the signal generated by such event in a different way according to the operating program which is active at that time. More particularly, if the signal is emitted after a time Δt has elapsed greater or equal to a prefixed time t_u from the last discontinuity or bump signal, the spiral operating mode is started, whereby the emission of the signal results in the apparatus stop, a 180° rotation and a forward motion for a time equal to $\Delta t/2$, after which the apparatus stops again and begins to move with a spiral motion. In practice, in this way the apparatus starts the spiral motion approximately from the middle of the segment uniting the last two encountered obstacles. If the bump or the discontinuity due to a stair step are detected when the apparatus is already in the spiral operating mode, the apparatus stops and performs a 90° rotation to start the random operating mode passing along a radial trajectory through the center of the spiral followed up to that time.

In the case of a bump in the random operating mode, the forward motion of the apparatus is stopped and started a rearward motion for a prefixed time T_r, at the end of which the apparatus stops again and performs a rotation of

a random angle δ comprised between two prefized end values δ_1 and δ_2 (for example between 60° and 160°). Afterwards, the apparatus starts again in the random operating mode. The rotation of the angle δ always occurs in the same direction, until it is denied by the presence of an obstacle; from this time on the rotation always occurs in the opposite direction, until it is denied by a new obstacle.

In this case, unless the silent operating mode is on, during the time T_r of the rearward motion the fan is activated for the removal of the dirt and is shut off at the end of the rearward motion.

As a last case, the collision or detection of the discontinuity due to a stair step can occur when the room change operating mode has been activated, i.e. when a time T greater than time Tc of permanence in the same room has elapsed. In this case the apparatus stops, performs a rotation of an angle α comprised between 90 and 180°, in particular 135°, and starts again running along a closed curvilinear trajectory, in particular a repeated semi-circular trajectory. If the last bump was against a wall, it repeats the sequence at each subsequent bump against the same wall while performing semicircular trajectories, until a doorway is reached and the trajectory arc β is greater than 180°, this being further increased of an angle γ comprised between 30° and 90° up to a total angle of 270° maximum, after which the apparatus begins to clean the new room it has reached.

Figure 10 shows the operating mode when the apparatus encounters a carpet. If the apparatus is programmed to work in the silent mode or in a mode which does not include the carpet cleaning operation, the carpet

detection signal is considered as an obstacle detection signal, i.e. a collision signal, and handled as previously described. Instead, if the carpet cleaning function is active, plate 11 is lifted, the dispensing of the detergent liquid is interrupted and suction is started, before keeping on working on the carpet in the standard work conditions. Leaving the carpet can be detected via software in a conventional heuristic way or by means of a dedicated proximity sensor.

When the charge level of the batteries goes below a prefixed value, the room change mode is started and the apparatus reaches the first available doorway (Fig. 11). If the apparatus is manually rechargeable, it stops immediately at the doorway and emits an alarm signal. If the apparatus is automatically rechargeable, the apparatus keeps on running along the walls according to the room change mode until the guide of the recharge station is found on the floor surface. Once the guide has been found, the apparatus aligns itself thereon and follows it until it enters the recharge station. The guide is formed by a strip of plastic material extending on the floor for some length from the recharge station and embodying a conductor wherein a current flows. The contacts for the recharge can be located in a suitable position on the top side of the external body or on the sides thereof. The apparatus is provided with a suitable sensor, not shown, for detecting the conductor of the guide and emitting a signal which is sent to the apparatus driving system.

The driving system controls the speed of the apparatus as a function of the frequency of the collision/discontinuity signals which are generated, whereby the speed is increased after a prefixed time from

the last received signal has elapsed. Likewise, if the bumps become too frequent, the selection range for random angle δ is properly reduced.

In order to make easier the movements of the apparatus according to the invention, it may be equipped with a remote control (for example, of the joy-stick type) by means of which it is possible to transfer it to the working area, without the need of carrying it there, or even to interrupt its operation at any time.

Several variations and modifications can be brought to the floor cleaning apparatus according to the invention. In particular, there can be used sensing devices both of a collision and a floor discontinuity which are different from those used in the above described embodiment of the invention and selected by virtue of their structural simplicity and low cost only. Likewise, the arrangement of the various components on the apparatus frame may be varied with respect to that shown above as a function of the apparatus design which can limit the space availability. The external shape of the apparatus may also be varied without changing the innovative concept of the invention. These and other modifications which may be brought to the floor cleaning apparatus according to the present invention fall within the scope of the invention as set forth in the annexed claims.

CLAIMS

1. Apparatus for cleaning floors comprising: a support frame (1) mounted on wheels (2,10), a pair of which (2) is coaxially and independently motor driven, and carrying battery feeding means (4) of the rechargeable type; suction means (5,6) connected to a suction port (9a) through air filtering means (8), said suction port being directed toward the floor and placed near a front part of the frame, with respect to a forward motion direction, before brush means (13) for dirt collection; an outer body (41) elastically mounted on said frame and associated sensing means (15) for detecting a collision of said body against possible obstacles; sensing means (20,21) for detecting discontinuities of the floor to be cleaned located at the front part of the frame; and processing means (35) for controlling the apparatus operation; characterized in that it further comprises floor cleaning element support means (11) slidably connected to said frame in such a way to be kept into contact with said floor or to be raised therefrom, said floor discontinuity sensing means (20,21) comprising at least a sensor (20) for detecting discontinuities of a thickness lower than the minimum distance of said body (41) from the floor and generating a signal for raising said cleaning element support means (11), said processing means (35) being designed to convert the operation of the apparatus from a random operating mode to a spiral operating mode as a function of the time elapsed between two subsequent collisions, to stop the motion in one direction following a collision signal or a floor discontinuity signal and to start the movement in an opposite direction, to start a change room function when a prefixed time in a certain

room has elapsed, to generate an operating signal for raising said cleaning element support means (11) following a discontinuity signal due to a carpet, as well as to start a recharge station search function when the battery charge level goes below a prefixed value.

2. The cleaning apparatus according to claim 1, wherein said cleaning element support means (11) comprise a plate (11) held by at least a pair of stems (12) slidable within guides (1a) formed on said frame (1), and actuating means (23) integral to said frame and connected to said plate to control the sliding motion of said stems.

3. The cleaning apparatus according to claim 2, wherein said plate (11) is automatically liftable when a floor discontinuity of a thickness lower than the minimum distance of said body (41) from the floor is encountered.

4. The cleaning apparatus according to claim 1, wherein said floor discontinuity sensing means (20,21) further comprise a pair of sensors (22) for detecting a lack of support surface on the floor in the forward motion direction, said sensors (22) being placed at the front end thereof.

5. The cleaning apparatus according to anyone of the previous claims, wherein said frame (1) is frontwise supported by a pair of wheels (10) freely pivotable around there own axis and round an axis perpendicular to the floor, said pair of sensors (22) for detecting a lack of support surface in the forward motion direction being arranged before them.

6. The cleaning apparatus according to anyone of the previous claims, wherein said plate (11) is formed with passages for dispensing a sanitizing fluid, a detergent or the like on the cleaning element supplied from a tank (30)

integral to the frame through a metering pump (31).

7. The cleaning apparatus according to anyone of the previous claims, wherein said frame comprises a bottom wall (1b) on which opening (34) are formed for evacuating the sucked air and directing it toward the floor.

8. The cleaning apparatus according to anyone of the previous claims, wherein, in the front part of the frame, a chamber (7) is provided in which a filtering bag (8) for collecting the dirt is placed, said bag being connected to a suction duct (9) extending from said chamber and having a suction outlet (9a) directed toward the floor, said chamber further communicating with a fan (6) for sucking the air contained therein.

9. The cleaning apparatus according to anyone of the previous claims, further comprising a remote control device for its operation.

10. The cleaning apparatus according to anyone of the previous claims, further comprising a control panel (37) with a display (38), a control board (39) and a serial connection (36) for the connection to a computer for updating the driving software.

11. A method for controlling the operation of a cleaning apparatus according to anyone of the previous claims, characterized in that it comprises the following steps:

a) while the apparatus is moving in a certain direction, if a collision signal from a collision sensor (15) or a flow discontinuity signal due to a stair step from a discontinuity signal (22) is received, generating a control signal for stopping the forward motion in said direction;

b) if the apparatus is working in the random mode and the time interval (Δt) between said collision or discontinuity

signal and the last received signal of the same type is lower or equal to a prefixed value (t_u), proceeding in the reverse direction for a prefixed time (T_r), then performing a rotation of a random angle (δ) comprised between two prefixed values and moving forward in the new direction;

c) if the time interval (Δt) between said collision or discontinuity signal is greater than said prefixed value (t_u), performing a rotation of 180° then proceeding forward for a time equal to the middle of said time interval, then stopping the forward motion and restarting in the spiral mode;

d) if the collision or discontinuity signal is detected when the apparatus is in the spiral mode, performing a rotation of 90° toward the center of the spiral and proceeding in the new direction in the random mode;

e) if the collision or discontinuity signal is detected when the apparatus reaches a prefixed time (T_c) of permanence in a certain room, performing a rotation of an angle comprises between 90° and 180°, then covering a closed curvilinear trajectory and, when a subsequent bump occurs, repeating the sequence until the angular width of such closed curvilinear trajectory overcomes 180°, and then restarting in the random mode;

f) if the collision or discontinuity signal is detected when the charge level of the apparatus battery is found below a prefixed value, operating as in step (e) until a battery recharge station is reached.

12. The control method according to claim 11, wherein the rotation of said random angle (δ) always occurs in the same direction until it is prevented by an obstacle, afterwards it always occurs in the opposite direction

until it is prevented by another obstacle and so on.

13. The control method according to claim 11, wherein said recharge station is found through a signal emitted thereby for guiding the apparatus to engage within said station.

14. The control method according to claim 11, wherein in step (b) a suction step is started before beginning the reverse motion and is stopped at the end of the reverse motion.

15. The control method according to claim 11, further comprising the following steps:

g) while the apparatus is moving in a certain direction, upon receiving a floor discontinuity signal from said discontinuity sensor (20), said discontinuity being formed by a carpet or the like, if the apparatus is operating in the silent mode or in the carpet non-cleaning mode, considering this signal as a collision signal and proceeding according to what provided for in claims 11-14;

h) if the apparatus is in the carpet cleaning mode, generating a control signal for sliding said stems (12) for supporting said plate (11) to raise it from the floor;

i) detecting when the carpet is left by means of software or dedicated sensor;

l) lowering again said plate (11).

16. A method for cleaning floors by means of an autonomous cleaning apparatus according to any of claims 1 to 10, characterized by the following steps:

a) moving forward said apparatus along a rectilinear trajectory on said floor until signal indicative of a collision with an obstacle or of the presence of a discontinuity thereon is emitted;

b) stopping the forward motion of the apparatus except when said discontinuity is a carpet and a carpet cleaning

function is activated;

c) if the time (Δt) between the actual signal and the last detected collision or discontinuity signal is greater than a prefixed time (t_u), performing a 180° rotation of the apparatus, moving forward according to a rectilinear trajectory for a time equal to ($\Delta t/2$), stopping the motion of the apparatus and moving forward with a spiral motion from the point where it has been stopped; or

d) if the time (Δt) between the actual signal and the last detected collision or discontinuity signal is lower or equal than a prefixed time (t_u), activating a reverse motion for a prefixed time (T_r), rotating of a random angle comprising between 60° and 160° and then proceeding according to a rectilinear trajectory, during the reverse motion a dirt suction system being activated.

17. The method according to claim 16, wherein, after said actual collision or discontinuity signal a time (T) of permanence in a prefixed room to be cleaned is measured and, if it is greater than a prefixed time (T_c), the apparatus is rotated of an angle comprised between 90° and 180°, then is moved forward according to an arc trajectory until a subsequent collision or discontinuity signal is detected, detecting the width of the covered arc and, if it is greater than 180°, a further arc of curve is caused to be covered comprised between 30° and 90° and then the apparatus is moved forward according to a rectilinear trajectory; instead, if the covered arc of curve is lower or equal to 180° the forward motion is stopped and repeated the operating sequence.

18. The method according to claim 16, wherein, if the carpet cleaning function is activated, the further steps of raising the cleaning element supporting plate, shutting

down the metering pump of the sanitizing or detergent liquid and activating the dirt suction function are provided.

19. The method according to anyone of claims 16-18, wherein, after each collision or discontinuity signal, the battery charge level is measured and, if it is found lower than a prefixed value, the apparatus is displaced of an angle comprised between 90° and 180°, then is moved forward according to an arch trajectory until a guide for a recharge station is found or a successive collision or discontinuity signal is detected, in this second case the width of the arc of the covered curve is measured and, if it is lower or equal to 180°, the forward motion is stopped and the operating sequence is repeated, if greater than 180° the rotation is continued until a subsequent collision occurs and then the apparatus is stopped and the operating sequence repeated until said guide is found, in correspondence of which the apparatus stops, aligns therewith and follows it until it enters the recharge station.

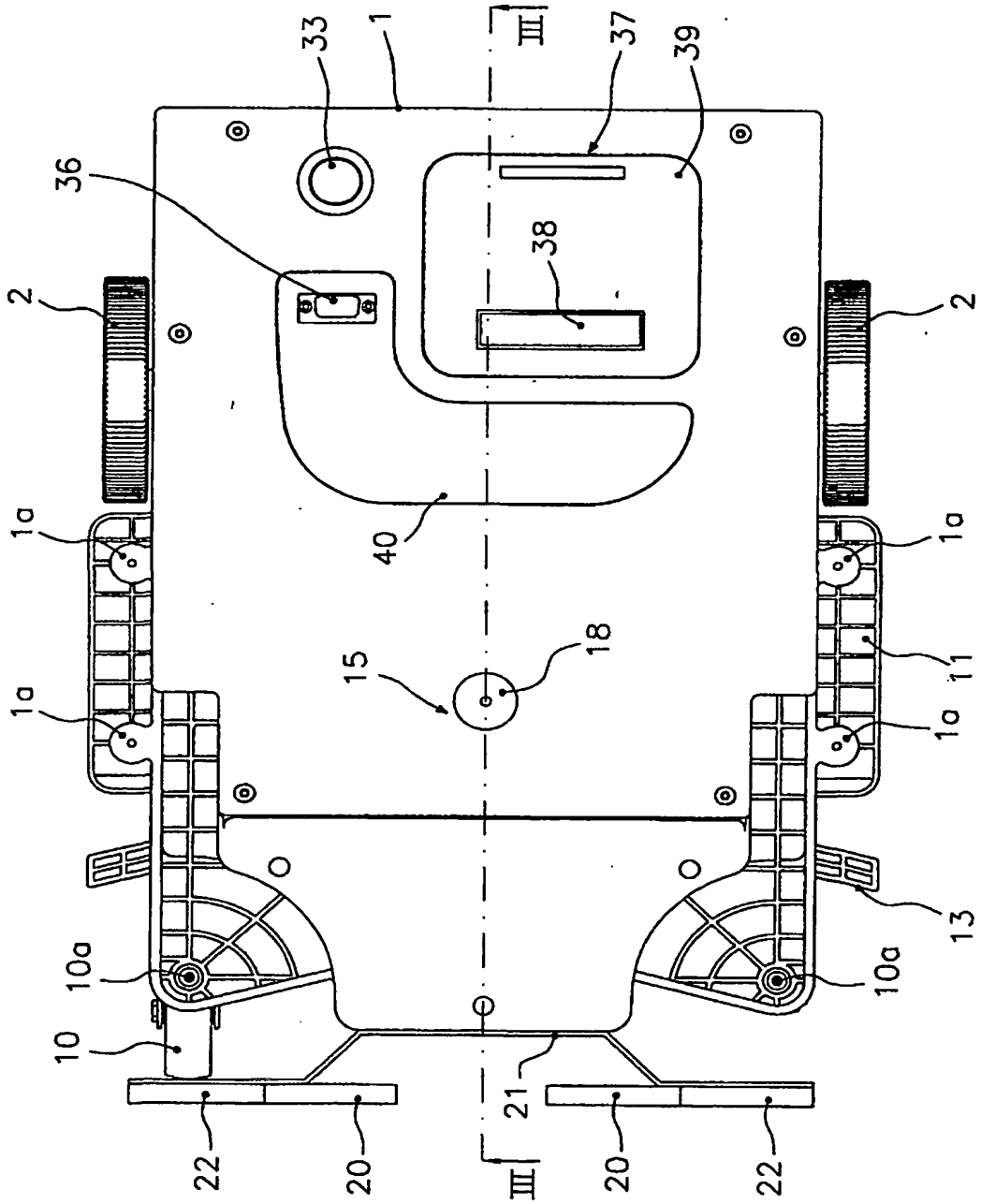
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Fig.1

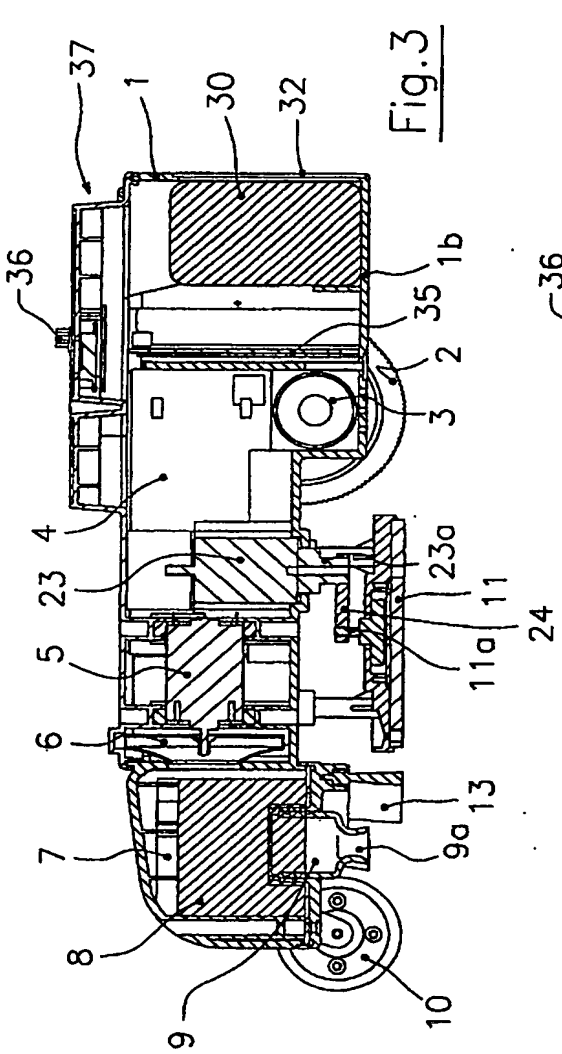
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Fig.3

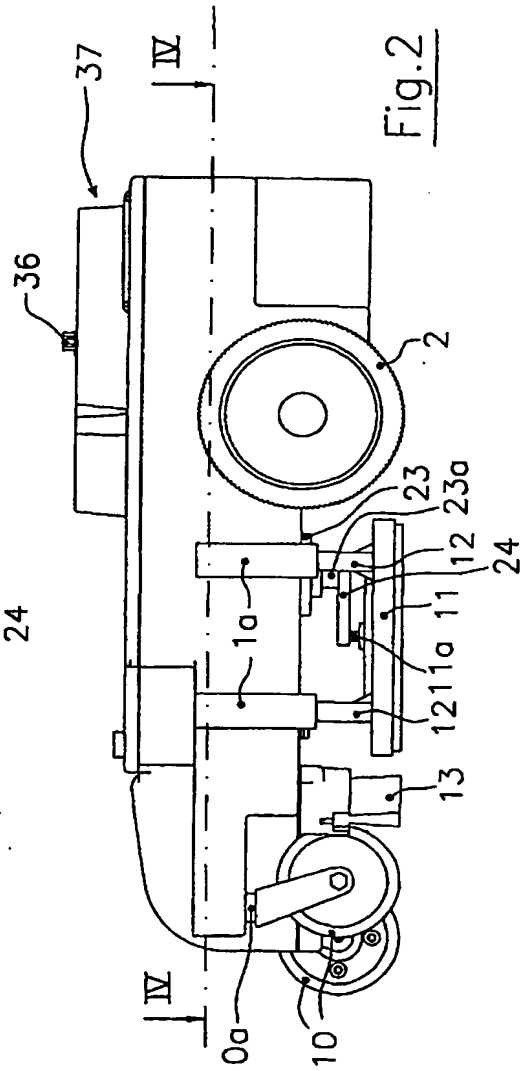
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Fig.2

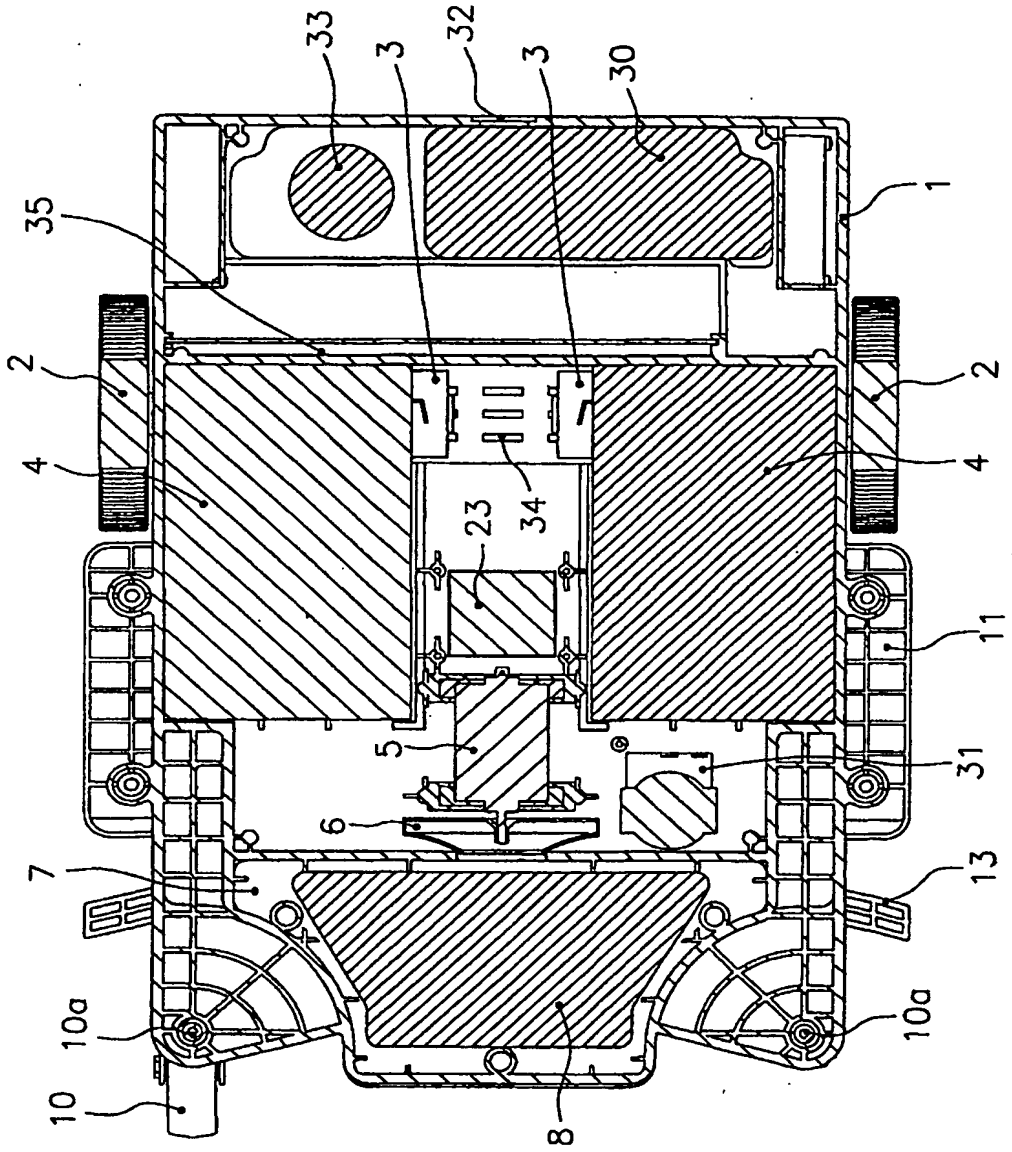

Fig.4

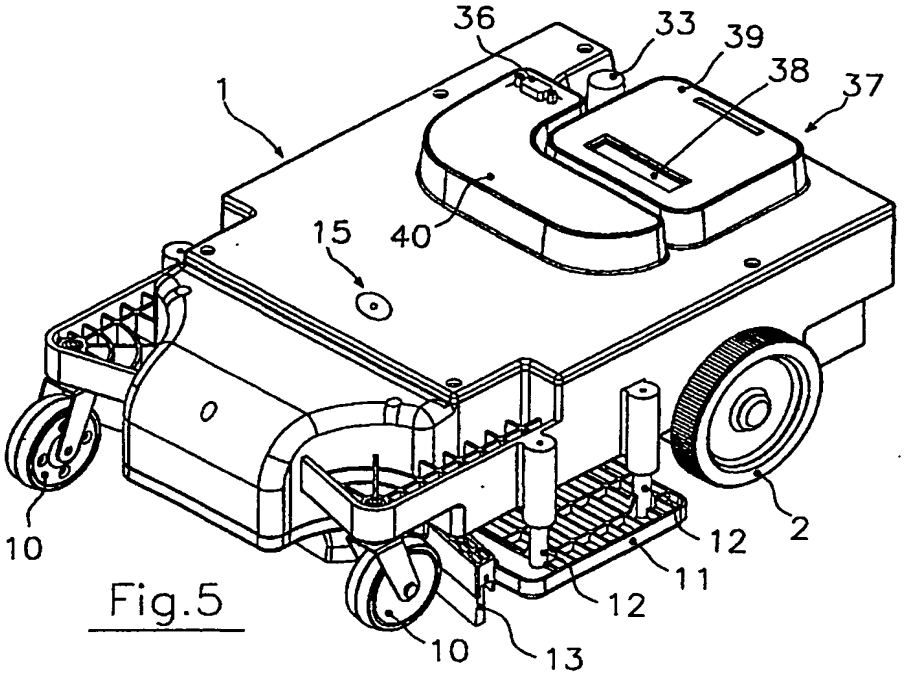
36
33
39
38
37
1
15
40
10
12
2
11
12
10
13

Fig.5

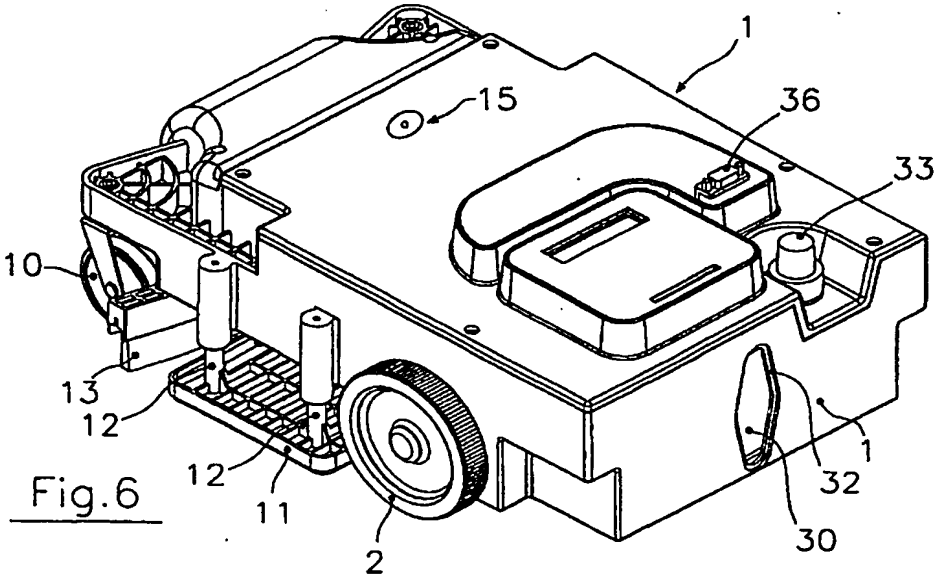
1
15
36
33
10
13
12
12
11
2
1
32
30

Fig.6

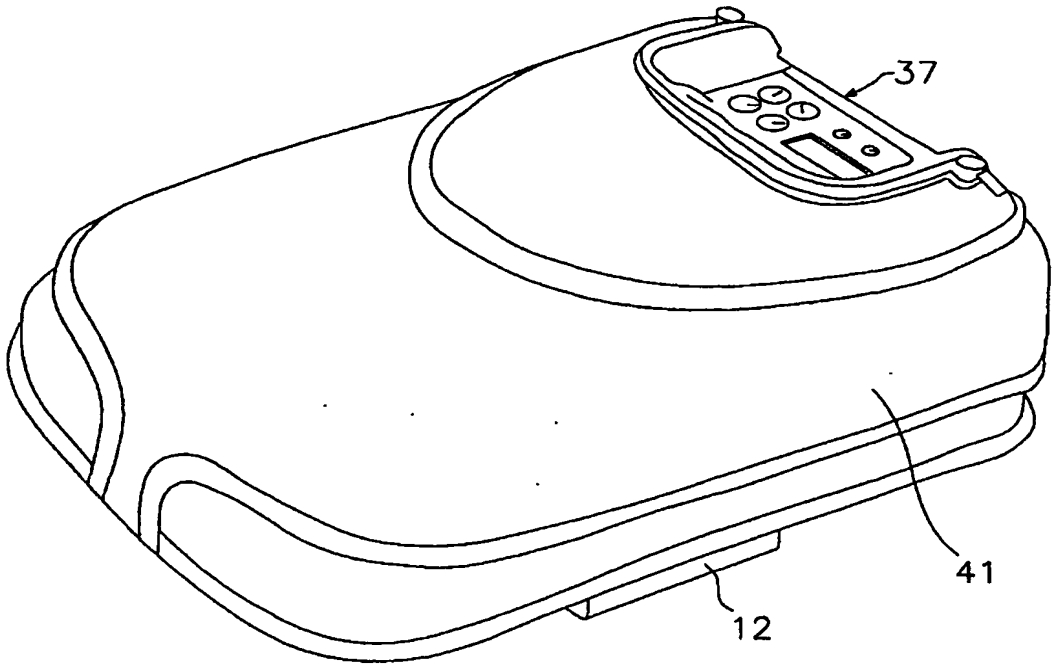

Fig.7

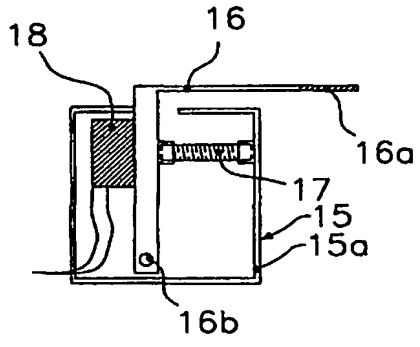

Fig.8a

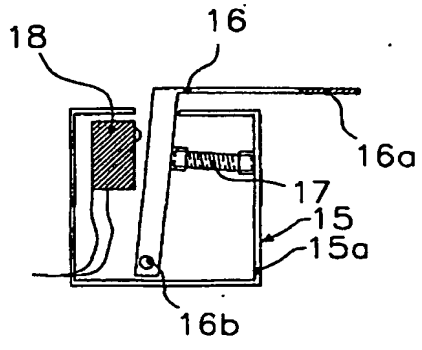

Fig.8b

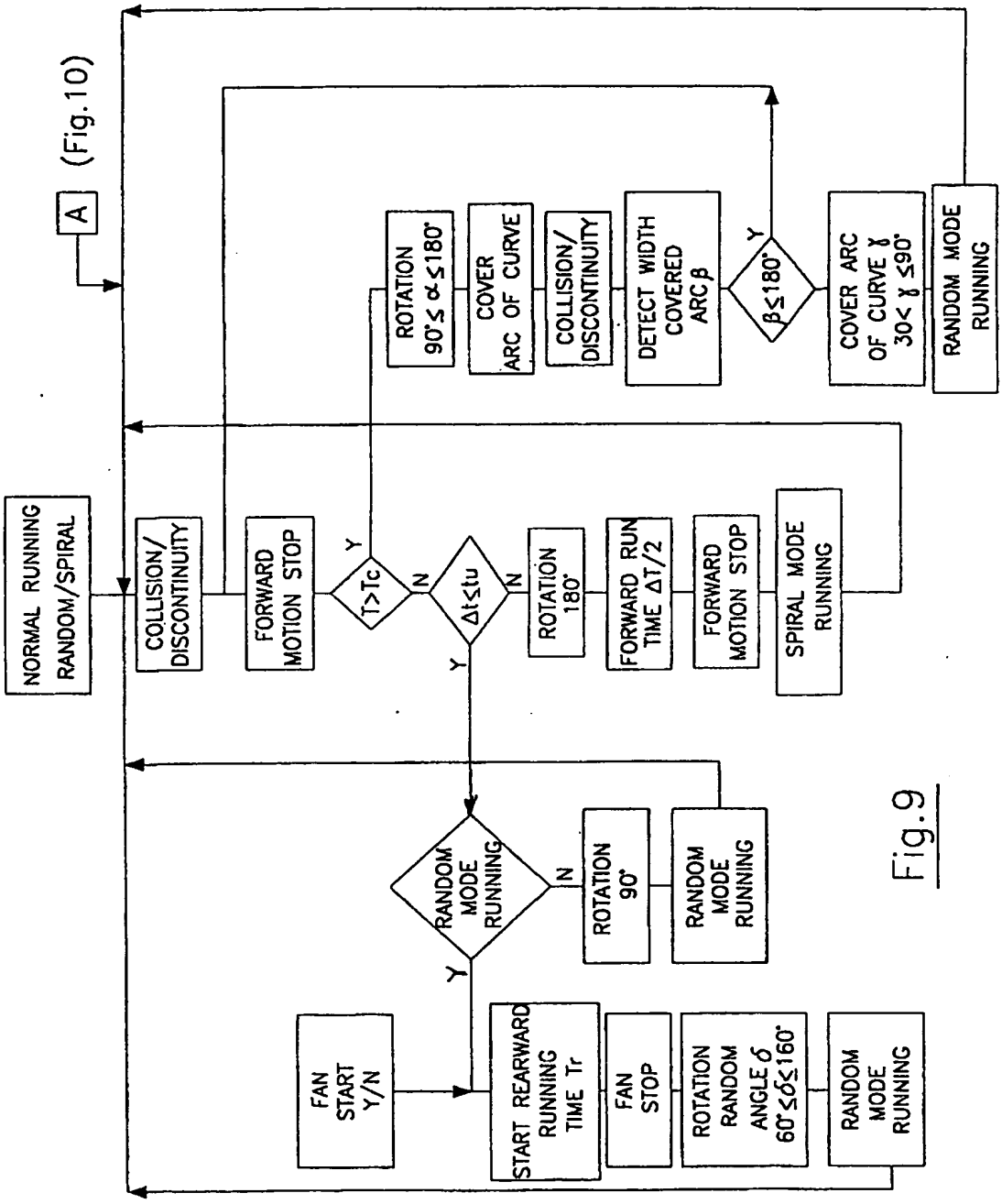
NORMAL RUNNING RANDOM/SPIRAL
COLLISION/ DISCONTINUITY
FORWARD MOTION STOP
T>Tc
Y
N
Δt≤tu
N
Y
ROTATION 180°
FORWARD RUN TIME ΔT/2
FORWARD MOTION STOP
SPIRAL MODE RUNNING
ROTATION 90°≤α≤180°
COVER ARC OF CURVE
COLLISION/ DISCONTINUITY
DETECT WIDTH COVERED ARC β
β≤180°
Y
COVER ARC OF CURVE γ 30<γ≤90°
RANDOM MODE RUNNING
A
RANDOM MODE RUNNING
N
ROTATION 90°
RANDOM MODE RUNNING
Y
FAN START Y/N
START REARWARD RUNNING TIME Tr
FAN STOP
ROTATION RANDOM ANGLE δ 60°≤δ≤160°
RANDOM MODE RUNNING

Fig.9

(Fig.10)

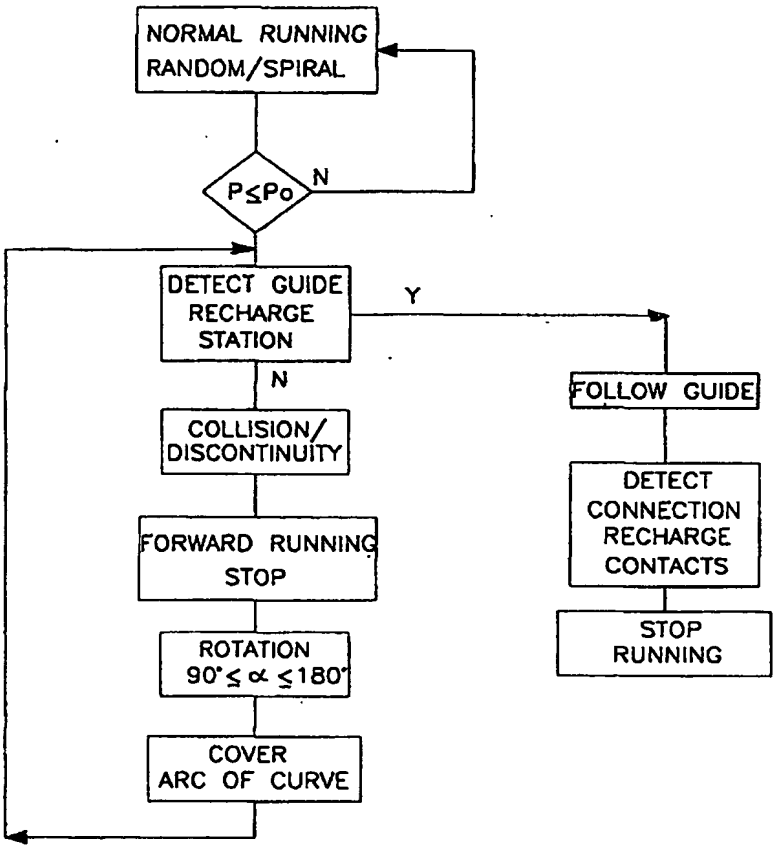
NORMAL RUNNING
RANDOM/SPIRAL
P≤Po
N
DETECT GUIDE
RECHARGE
STATION
Y
N
FOLLOW GUIDE
COLLISION/
DISCONTINUITY
DETECT
CONNECTION
RECHARGE
CONTACTS
FORWARD RUNNING
STOP
STOP
RUNNING
ROTATION
90°≤ α ≤180°
COVER
ARC OF CURVE

Fig.11

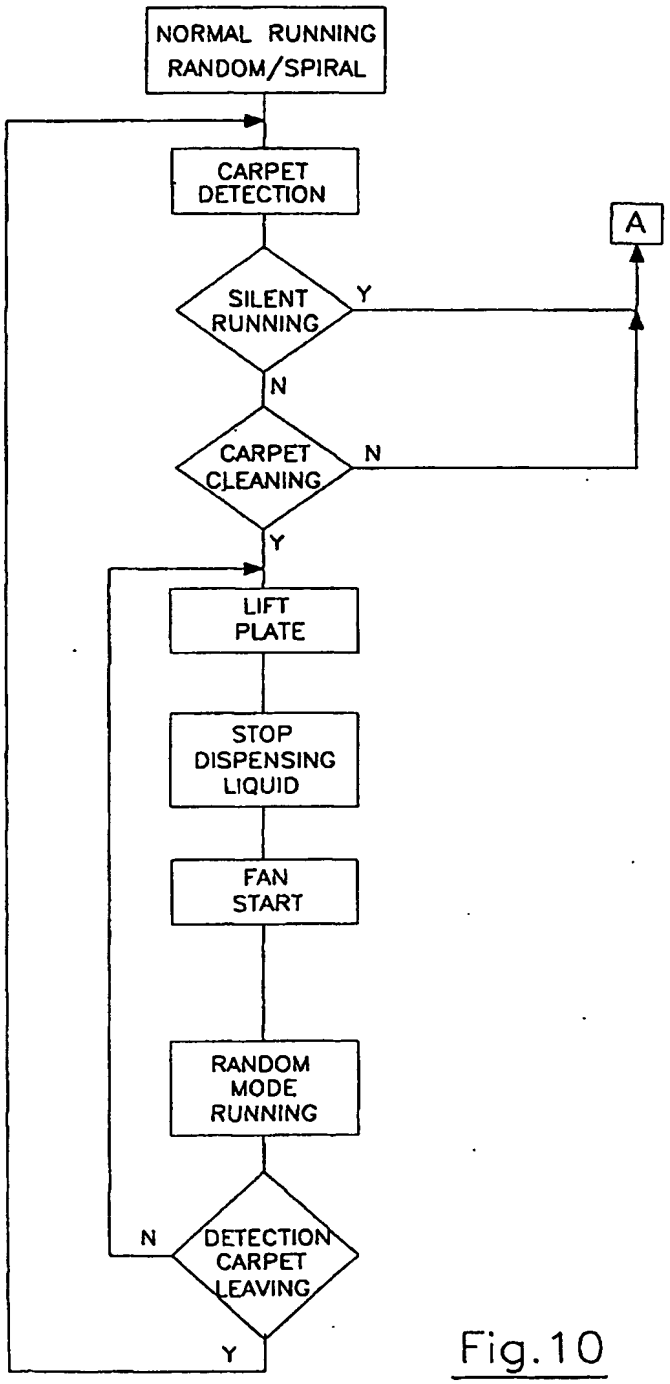
NORMAL RUNNING
RANDOM/SPIRAL
CARPET DETECTION
A
(Fig.9)
SILENT RUNNING
Y
N
CARPET CLEANING
N
Y
LIFT PLATE
STOP DISPENSING LIQUID
FAN START
RANDOM MODE RUNNING
N
DETECTION CARPET LEAVING
Y

Fig.10

INTERNATIONAL SEARCH REPORT

Int >nal Application No
PCT/IT 01/00573

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A47L11/40 A47L9/28 A47L11/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A47L G05D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 00 04430 A (BOTTOMLEY I ET AL) 27 January 2000 (2000-01-27) cited in the application abstract page 6, paragraph 4 -page 7, paragraph 1 page 8, paragraph 2 - paragraph 3 page 11, paragraph 5 -page 12, paragraph 1 page 12, paragraph 3 - paragraph 4 page 13, paragraph 4 figures 1,2	1,11,16
A	US 5 781 960 A (KILSTROEM L ET AL) 21 July 1998 (1998-07-21) cited in the application abstract column 3, line 29 - line 50 figures	1,11,16

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 April 2002	12/04/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Cabral Matos, A

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 940 927 A (HULDEN J ET AL) 24 August 1999 (1999-08-24) cited in the application abstract figures	1,11,16
A	US 5 568 589 A (HWANG J S) 22 October 1996 (1996-10-22) cited in the application abstract figures	1,11,16
A	GB 2 344 900 A (NOTETRY LTD) 21 June 2000 (2000-06-21) abstract page 4, line 14 -page 5, line 10 figures	1,11,16
A	US 5 204 814 A (NOONAN T H ET AL) 20 April 1993 (1993-04-20) abstract column 6, line 7 - line 18 figures 1A-1C	1,11,16
A	US 5 815 880 A (NAKANISHI H) 6 October 1998 (1998-10-06) abstract column 6, line 59 -column 7, line 16 column 7, line 26 - line 33 figures 5-7	1,11,16
A	US 5 787 545 A (COLENS A) 4 August 1998 (1998-08-04) abstract column 1, line 7 - line 15 column 3, line 20 - line 27 figures 4-6	1,11,16

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int onal Application No
PCT/IT 01/00573

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 0004430	A	27-01-2000	AU	4999899 A	07-02-2000
			BR	9912304 A	02-05-2001
			EP	1099143 A1	16-05-2001
			WO	0004430 A1	27-01-2000
US 5781960	A	21-07-1998	SE	509317 C2	11-01-1999
			EP	0803224 A2	29-10-1997
			SE	9601576 A	26-10-1997
US 5940927	A	24-08-1999	SE	506372 C2	08-12-1997
			AU	710171 B2	16-09-1999
			AU	2797397 A	19-11-1997
			CA	2224735 A1	06-11-1997
			DE	69701375 D1	13-04-2000
			DE	69701375 T2	10-08-2000
			EP	0841868 A1	20-05-1998
			ES	2144861 T3	16-06-2000
			JP	11508810 T	03-08-1999
			SE	9601658 A	31-10-1997
			WO	9740734 A1	06-11-1997
US 5568589	A	22-10-1996	KR	9407727 B1	24-08-1994
			DE	4307125 A1	16-09-1993
			JP	6014857 A	25-01-1994
GB 2344900	A	21-06-2000	AU	1575300 A	12-07-2000
			GB	2361553 A	24-10-2001
			WO	0038025 A1	29-06-2000
US 5204814	A	20-04-1993	NONE		
US 5815880	A	06-10-1998	JP	9047413 A	18-02-1997
US 5787545	A	04-08-1998	BE	1008470 A3	07-05-1996
			AT	184773 T	15-10-1999
			AU	3073095 A	25-01-1996
			WO	9601072 A1	18-01-1996
			DE	69512414 D1	28-10-1999
			DE	69512414 T2	05-01-2000
			DK	769923 T3	03-04-2000
			EP	0769923 A1	02-05-1997
			ES	2138227 T3	01-01-2000
			GR	3032193 T3	27-04-2000
			JP	10502274 T	03-03-1998